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Investigative Report
Intermountain Region

June 1, 1935

REPORT OF THE

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

1934-1935

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REGIONAL INVESTIGATIVE COMMITTEE REPORT

Introduction

The annual investigative committee meeting was held in the Regional Office at Ogden, Utah on April 2, 1935. The presentation of the results of the past year and plans for the future was confined to one day, in view of the large amount of urgent emergency work being carried by those in attendance. Special effort was made to point out the significance and application of results from the administrative standpoint and in this connection it was found advantageous to classify the Station's work under three general heads, namely: (1) current administrative problems that can and should be solved by studies of short duration which are to be undertaken as the expediency arises; (2) administrative problems of long standing that require intensive study over a considerable period of time; and (3) academic problems that require fundamental research as a basis for studies with direct practical applications.

Recent developments in the general field of forestry gave cause for more than the usual amount of interest in numerous problems now being studied or being contemplated by the Station. The results of and recommendations for timber stand improvement and erosion control work as devised by the Station were of special interest in connection with proposed work for the Civilian Conservation Corps. The results of grazing studies both on the national forests and on the public domain were particularly desired because of the present trends

toward social and economic planning involving the use of the natural resources. Information on the status of cut-over lands in the Intermountain Region and a compilation of selective logging data was definitely correlated with present and proposed activities of the Lumber Code Administration. Present and proposed studies on erosion and water yield were brought to the fore by the extreme drought conditions of 1934, and for the same reason the results of studies dealing with forest fire behavior and damage were very apropos.

It was recognized that the added impetus given to investigative work by the emergency program of the past two years has done much toward a better understanding of many of the forest and range problems of the Intermountain Region. Some regret was expressed, however, that the information derived from various studies was not being disseminated fully enough in the region. In order to overcome this difficulty, it was suggested that brief, composite outline reports of current results be mimeographed and distributed for administrative use. Recommendations were made, also, for supervisors' and rangers' meetings at which the results and progress of the Station's work would be reviewed and illustrated.

Several new projects were suggested to the meeting and received with approval providing sufficient emergency funds could be made available to undertake the studies on a satisfactory scale. A brief discussion of the progress and plans for future studies as outlined at the investigative committee meeting is appended herewith.

STATION PERSONNEL

The regular and emergency personnel assigned to various projects are as follows:

Overhead

Regular

Reed W. Bailey, Director (April 1, 1935)
W. E. Mann, Chief Clerk
Marguerite A. Israelson, Clerk
Blanche Hoxsie, Assistant Clerk

Emergency

Byron F. Thurmond, Surveyor-Draftsman
E. P. Phillips, Laboratory Technician
Herbert Burrell, Principal Clerk
Leona H. O'Donnell, Assistant Clerk
Mary A. Monson, Assistant Clerk
Wilma Rubenstein, Assistant Clerk
T. L. Livingood, Assistant Clerk
Lowell Woodward, Laboratory Assistant

Forest Management

Regular

C. A. Connaughton, Silviculturist
E. L. Mowat, Junior Forester

Emergency

Technicians

H. S. Hinkley
W. B. Read

Junior Forester

L. H. Carlson

Assistant to Technicians

Lewis Clark
C. A. Fawcett
T. C. Pender

Range Management

a. Desert Shrub Range

Regular

Dr. George Stewart, Senior Forest Ecologist
Selar S. Hutchings, Assistant Range Examiner

Emergency

Wesley Keller (On leave at University of Wisconsin doing graduate study.).

Assistant Conservationist

Ira Clark
John W. Carlson

Technicians

Ben R. Stahmann

Junior Range Examiner

James Jacobs

Assistant Technicians

Howard Farnsworth
Victor A. Surface

b. Sagebrush-Wheatgrass Range

Regular

Dr. George Stewart, Senior Forest Ecologist.
G. D. Pickford, Forest Ecologist
J. F. Pechanec, J.R.E. (detailed from Great Basin Branch)

Emergency

Junior Range Examiner

Alvin V. Steed

Assistant Technician

Talmage Nelson
Henry Ward
Sylvan Warner

c. Summer Range - Wasatch Branch

Regular

Raymond Price, Assistant Range Examiner

Collaborators

E. C. McCarty
Sylvia Griswold

Emergency

Assistant Conservationist

David Costello

Technician

James Hockaday

Assistant Technician

James C. Ensign

Assistant Observer

Robert B. Evans

Erosion - Streamflow

Regular

Geo. W. Craddock, Senior Range Examiner
C. K. Pearse, Associate Range Examiner
A. R. Croft, Assistant Range Examiner

Collaborator

Liter E. Spence

Emergency

Assistant Conservationist

Verne W. Stambaugh

Techniciam

Kenneth W. Daniels
Wallace M. Johnson

Junior Civil Engineer

L. K. Hill

Assistant Technician

Maurice W. March
Foyer Olsen
Howard Peterson
George A. Tribbey
Samuel Woolley

FOREST MANAGEMENT (Silvical Research)

Forest management investigations during the past year have benefited greatly by the availability of emergency funds and all phases of the work have progressed in a rapid and successful manner. As in the past the work has been concentrated largely on the broad aspects of methods of cutting and reproduction of ponderosa pine. This major project has been supplemented, however, with several closely related subprojects which have been undertaken as matters of expediency to furnish information pertaining to current local problems. Progress during 1934 and plans for 1935 are as follows:

Progress

1. Ponderosa pine experimental forest survey and improvements

Timber surveys and maps of the experimental forest were completed. The forest is divided logically into two major drainages, one supporting approximately 35 million board feet of virgin timber and the other supporting nearly 9 million board feet of cut-over timber. The average stand per acre on these two areas is 14,500 and 5,800 board feet, respectively. Major roads were constructed on these areas and tentative plans prepared for a thorough utilization road system. Intensive insect control work was undertaken and all insect infestations definitely reduced to an emdemic state.

2. Methods of cutting ponderosa pine sample plots

All preliminary work on the seven 10-acre permanent sample plots established on the experimental forest in 1933 was completed.

Trees were given final numbers, logging damage checked, reproduction and vegetation transects tallied, post-logging photographs taken and slash disposal completed.

3. Study of selective cuttings in the ponderosa pine type in Central Idaho

Since 1932 a series of surveys has been made of all important cut-over areas in the ponderosa pine type in central Idaho. The object of this study is to determine the growth rates and status of the residual stands and natural reproduction which has followed the various degrees of cutting practiced on both national forest and private lands. In addition to the data derived from these surveys a series of sample plots has been remeasured and information obtained from these plots is to be correlated with the more empirical survey data.

During the past year the initial phase of this study was completed by the preparation of two reports dealing with sample plot data. The first of these reports dealt with a series of sample plots established on the Payette National Forest in 1913. It was found the average annual net growth on these plots was 139 board feet on a reserve stand of 3,184 board feet per acre. The other report summarized the results of series of measurements on a sample plot on the Salmon National Forest where it was found that the average annual net growth had been 164 board feet on a reserve stand of 6,753 board feet per acre.

Compilations of the cut-over cruise data have progressed and the most interesting results available at present concern natural reproduction on the various areas. On the basis of the stocked-quadrat method of inventory it has been surprising that cutting caused only a slight reduction in stocking. This reduction ranged from only 3 to 7 percent on national forest sale areas to only 20 percent on heavily cut-over private land. Subsequent reproduction has been discouragingly light, however, and only in one instance where the cutting was made 28 years ago on national forest land has the reproduction made up for the initial loss from cutting.

Final results of this study will be available in a major report within the next year.

4. Accumulation and rate of melting of snow as influenced by a ponderosa pine forest cover

The initial phase of this study was brought to a close and a report has been published in the Journal of Forestry. It was found that the average annual interception of water in the form of snow in a stand of virgin timber having an understory of advance reproduction was 29.8 percent of the total winter precipitation. Similar figures for a stand of virgin timber having no advance reproduction and a rather open stand of reproduction 20 to 25 feet in height were 24.5 and 5.4 percent, respectively.

Interception varied with the age of timber stands, indicating that high, spreading crowns wastefully dissipated much of the winter precipitation. In this connection it was found that 33.5

percent of the winter's snowfall was intercepted by crowns of mature trees while only 18.3 percent was intercepted by crowns of reproduction and immature trees.

Small openings in the forest were found to be practically as effective in accumulating snow as large openings beyond the zone of any forest influence.

Snow melting was significantly retarded by a crown canopy. In the stand of advance reproduction and in the stand of mature timber having an understory of reproduction the snow disappeared 8 days later than it did on a denuded area. In the stand of mature timber having no advance reproduction, melting was retarded only on the average of 4 days. A dense stand of sagebrush which was studied in this connection had very little influence in retarding melting.

It appears from this study that maximum yields of water can be expected from deforested watersheds, but that the resulting streamflow would be unregulated and subject to high peak flow early in the spring. A forest cover most suitable for water yield from the standpoint of accumulation and rate of melting of snow appears to be a young stand, well interspersed with small openings in the crown canopy.

Additional study of this problem was undertaken in 1934 by establishing a series of snow courses on various aspects and sites and under various crown canopies, which have been modified by different methods of cutting.

5. Forest fires and accelerated erosion

A summarized report covering this subject has been published in the Service Bulletin and a more complete report has been accepted for publication by the Journal of Forestry. It was found by this study that irrespective of slope or intensity of burn 42 percent of the study plots established on a cut-over area following fire showed evidence of accelerated erosion. In a virgin stand the corresponding figure was 28 percent. When slope and intensity of the fire were considered it was evident that they were closely correlated with the acceleration of erosion following fire. Almost without exception it was found that as either slope or intensity of burn increased the resulting erosion also increased. On crown fire areas on slopes 50 percent and over more than 80 percent of the plots established showed accelerated erosion since the fire.

It is apparent from this study that the steep watershed lands of the Intermountain Region should be protected from fire if only from the standpoint of watershed management.

6. Fire damage in the ponderosa pine forests of central Idaho

This study of the 1931 Boise Basin fire has been summarized in a report which is now ready to submit for publication. It was found by this investigation that 73, 74 and 54 percent of the volume in virgin, cut-over and young growth stands, respectively, was either killed outright by fire or died as a result of injury or insect attacks. Delayed mortality following the fire was carefully studied and in the case of ponderosa pine it was found to equal

approximately 10 percent of the original stand. In case of Douglas fir the delayed mortality amoumted to 20 percent of the original stand, most of this mortality being attributed to fire damage to the roots of this species.

Reproduction was badly damaged by fire. On the virgin forest area, 87.5 percent of the total stand of reproduction was destroyed. Similar data for the cut-over and young growth areas were 85.6 and 61.2 percent, respectively.

Stocking on the basis of the stocked-quadrat method of sampling was reduced 84 percent in the virgin stand and 77 percent in the cut-over stand.

7. Timber stand improvement in the ponderosa pine type

A series of 25 stand improvement plots designed both for demonstration and experimental purposes were extablished on the ponderosa pine experimental forest. A report covering progress to date and recommending the practice of the crop tree method of improvement has been mimeographed and circulated widely throughout Region 4. The body of this report has formed the present timber stand improvement handbook now being used in this region.

8. Factors causing lower timber line in central Idaho

This study is a compilation of all existing literature pertinent to the above subject. Ponderosa pine ecology and physiology is quite fully covered and an effort is made to present the data so that certain fundamental concepts of the distribution of the species will be more clearly understood. Owing to the lack

of original research incorporated in this study no formal publication is contemplated. However, in view of the interest expressed by certain supervisors in Region 4, an effort will be made to circulate the report locally. A copy of the final report on the study has been submitted to the Washington office for review.

9. Evemaged ponderosa pine yield study

Approximately 50 evenaged ponderosa pine yield plots were established and the derived data submitted to the Pacific Northwest Station for compilation. The plots represent the Intermountain Region's contribution to the interregional evenaged yield study.

10. Reforestation

Thirty-five thousand ponderosa pine transplants were planted on an experimental basis in 1934. First-year results indicate that planting can be done successfully in the Intermountain Region if planting sites are selected carefully. In spite of the acute drought of the past year, first-year survival of selected sites reached 70 percent. On exposed, unfavorable locations there was no survival whatsoever.

11. Economic selective logging

At the request of Region 4, all literature on logging costs and selective logging has been reviewed. Information applicable to the Intermountain Region has been compiled into one comprehensive report and an example prepared illustrating how this information can be used by the Forest Service and private lumber operators.

12. Trends of moisture content in evergreen foliage during periods of drought stress

This study was undertaken in an attempt to ascertain factors which contribute to extreme fire hazard. The results have been unusual in that the moisture content of ponderosa pine foliage increases as drought stress becomes more acute, while the moisture content of Ceanothus foliage acts in an opposite manner.

It was found that on June 20 the moisture content of pine foliage averaged 99 percent. As the season progressed the moisture content increased until on August 19 a maximum of 117 percent was reached. After that date there was a steady decline until the study was closed in the fall. In the case of Ceanothus foliage the moisture content averaged 122 percent at the beginning of the study but throughout the summer there was a steady decline until a minimum of 90 percent was reached in late September.

Young leaves were found to be less desiccated than old leaves; trees growing on protected sites were less desiccated than those growing on south slopes, trees growing with their roots near a permanent stream became more desiccated throughout summer in contrast to the trends observed in trees growing apart from free water, and the foliage from the lower crown was found to be less desiccated than foliage from the upper crown.

Volatile oils in the foliage were studied also and no definite trend was observed. In fact, the volatile oil content of the foliage is so low that almost any trend would be of little significance.

In addition to the study of moisture content and volatile oil the foliage samples were analyzed for mineral nutrients. Significant trends of nutrients were observed with calcium and magnesium following in more or less an inverse ratio to potassium and phosphorous.

An explanation of the phenomena observed in this study is not forthcoming either from the data at hand or from existing literature on similar studies made elsewhere. A vast field for study has been disclosed, however, and detailed physiological investigations should be undertaken in this connection.

13. Fire weather

Cooperation with Region 4 in ascertaining and studying fire weather has been continued by maintaining and compiling necessary records.

14. Miscellaneous

A few miscellaneous undertakings merit mention apart from the studies listed previously. For example, a series of local volume tables has been prepared to facilitate methods of cutting studies; approximately 100 pounds of ponderosa pine seed were collected; nearly 100 seed traps were constructed, preparatory to an intensive study of natural reproduction; certain ecological studies such as the influence of slope on temperature and evaporation were started, and a minor study of the influence of a snow cover on tree growth was carried through the winter.

Plans for 1935

Plans for the coming year are in a somewhat nebulous state pending allocation of emergency funds. However, in order to be able to meet the fullest possible demands on the station, tentative plans are organized and presented here on the basis of maximum estimates.

1. In view of the emergency nature of much of our contemplated work, precedence will be given to collection of data which can be compiled and analyzed over a relatively short period. Particular emphasis will be placed on reports dealing with the methods of cutting and other data which are available at the present time.

2. An intensive study of all phases of natural reproduction will be initiated. Seed production, seed dissemination, natural seed beds, germination and survival will be studied under natural and controlled conditions. Emphasis will be placed on the factors associated with the uneven occurrence of ponderosa pine reproduction and what can be done to secure more favorable results. All recurrent phases of present methods of cutting studies which deal with natural reproduction will be investigated as part of this study.

3. Experimental work in timber-stand improvement will be continued on the experimental forests. These experiments will serve both as growth study plots and as demonstration areas.

4. Permanent fire damage plots and transects will be examined to determine vegetative trends following fire. In connection with fire, the age-old question of whether the brush cover and in turn the fire hazard has increased with protection, will be studied. This problem will be investigated by ring counts of lesser vegetation.

5. Root systems of ponderosa pine and associate species will be investigated as a supplement to methods of cutting and timber stand improvement studies.

6. It is anticipated that a field laboratory will be established to study certain phases of tree physiology. The most important questions to be investigated are further studies on trends of moisture content of evergreen foliage, power of conduction of water of various tree species, and nutrient and food stores in relation to periodicity of seed production.

7. The forest planting experiments undertaken in 1934 will be continued by reexamination of plantations and additional planting. Assistance will be furnished in the planting of erosion control areas in Utah.

8. At the request of Region 4, the station will assist in studying rate of fire line construction, rate of spread of fire and the use of chemicals in fire control.

9. It is contemplated that a small nursery will be established to furnish planting stock for experimental purposes.

10. Studies will be inaugurated in the lodgepole pine forests of Region 4. This phase of the work involves the location of an experimental forest, establishing a headquarters site, preliminary timber surveys, certain stand improvement measures and an investigation of existing cut-over areas in the Region in order to determine the efficacy of present silvicultural practices as applied to lodgepole pine.

11. Many old plantings that have been made in Utah have not been reexamined for 10 to 15 years. It is planned to reexamine many of these planting areas and to coordinate the information obtained with a study of methods of management which should be followed in either perpetuating or changing the large areas of temporary aspen types in the Region.

12. An economic survey of a few selected areas in Region 4 is contemplated and the forest management phases will be handled by this branch of the Experiment Station.

RANGE MANAGEMENT INVESTIGATIONS

SUMMER RANGE - WASATCH PLATEAU (GREAT BASIN BRANCH)

The availability of Nira and ECW Research funds during 1934 has made it possible to concentrate on the analysis of several old-established subprojects, some of which have been under investigation at the Great Basin Branch Station since 1912. No new work was initiated during the past year and in deference to needed office analysis, current field work was held to an absolute minimum.

Progress and plans for the summer range project are discussed by subprojects as follows:

Progress

1. The effect of climate on plant growth

a. Measurement of physical factors.

Records of air temperature and precipitation during the main growing season at three vegetative zones (oakbrush, aspen-fir and spruce-fir with elevations of 7,650, 8,850 and 10,170 feet, respectively) have been made almost continuously since 1914. In some instances these records are year-long. Records of evaporation, wind velocity, sunshine duration, relative humidity, soil temperatures and soil moisture determinations have been taken for short periods at some of each of the above stations.

All of the above-named records were compiled and summarized during the past season. A report of these summaries is now in process of completion for a possible Monthly Weather Review article.

It is planned to continue the field records of this phase since they form the basis for other projects and since a long-time record is essential to definitely formulate a working knowledge of climatic factors.

b. The effect of climate on plant development.

The results obtained prior to 1923 were published in Department Bulletin 1405.

From 1925 to 1932 phenological observations were made of several important summer range plants at varying elevations. Growth records of individual plants have been obtained from the start of growth in the early spring until these plants were covered with snow. From 1932 to 1934 inclusive, similar information was obtained on a limited number of key species.

Analysis of these data shows that the date of vegetative readiness for summer range, as determined by certain stages of development of range plants, has varied from 30 to 40 days between "early" and "late" years. This fluctuation is influenced mainly by the length of time that snow remains on the ground in the spring. Temperature and precipitation, following snow recession, also significantly influence the length of time between snow recession and vegetative readiness.

With each 10 to 14 days advance from normal in beginning of spring growth grazing may be practiced 1,000 feet higher in elevation. In the autumn the reverse is true. A late spring and an early autumn may cut the length of the grazing period in

half at the higher elevations. The length of growing period determines to a considerable extent the length of grazing period.

Following seed maturity, plants dry up faster at high elevations than at the lower altitudes. With favorable temperatures and precipitation, a considerable amount of aftermath growth may be produced by plants at low elevations, although the date of drying is subject to fluctuation.

By means of regressions, based on the relation of developmental stages to the date of snow recession vegetative conditions can be predicted from a few weeks to more than two months. On this basis, range management practices can be planned sufficiently far in advance of their actual operation to secure the most desirable utilization of the forage.

A report summarizing results of this study is now being prepared for a scientific journal. Further study and observations are necessary to refine this new method of forecasting and to make possible more accurate predictions.

c. The effect of climate on forage yield.

Annual records of yield for several of the most important plant associations have been kept continuously since 1924. These records were summarized during the past winter.

Results of this study show that variations in climate are wide enough to justify certain elasticity in range management plans. Total forage production for a season may vary as much as 120 percent above the normal in one year to 77 percent below in

another year. The time when grazing should begin may vary as much as 47 days. Total forage produced seems to be closely correlated with the amount of moisture in the soil at the time of growth inception plus the amount of precipitation that occurs prior to flower stalk formation. Any precipitation that falls after flower stalk formation does not seem to affect forage growth of the current year.

2. Improvement and maintenance of summer range lands by natural revegetation of native forage species

a. Maintenance and rehabilitation of summer range lands varying in degree of soil depletion and vegetative cover under different intensities of grazing.

Seventy-six quadrats, 71 major plots, and 7 intensively mapped areas have been established since 1914 in three vegetational zones on sites varying in degree of soil depletion, vegetative cover and intensities of grazing. These plots have been remapped and rechecked at intervals to determine the change of the native forage cover.

Results to 1922 were published in Departmental Bulletins 791 and 1405.

The data since 1922 have been compiled and analysis is under way.

Results to date show that natural revegetation is very slow, especially under the existing drought conditions, and is practically nil on areas that have been depleted of soil cover.

Analysis will be continued and a progress report completed. Field work will be held to an absolute minimum.

b. Successional study of Rudbeckia occidentalis.

A study was started in 1924 to determine the rate of invasion of niggerhead (Rudbeckia occidentalis) on protected and grazed areas. Two plots, each 33 x 33 feet, were selected, one protected and one open to grazing. All niggerhead plants on each plot were staked and numbered. In each successive year, from 1924 to 1934, all new plants were staked and recorded and the dead plants noted.

Present results show no significant difference in the rate of invasion of niggerhead on the two plots. The number of niggerhead plants on both areas has diminished during the last four years of the study indicating that these plants may be "losing out" in favor of grass species.

An examination will be made of the areas during the coming field season preparatory to finishing the study and completing a report.

c. The role of seed germination in plant succession.

Tests of seeding habits, seed production, seed dissemination and germination under various conditions of storage, temperature, and moisture relationships for 55 important range species were conducted during the period 1928-1933. The first draft of the report is completed and the final report will be ready for publication by early fall.

3. Degree of utilization as a factor in range management

A pasture was fenced on the high summer range lands at the head of Ephraim Canyon in 1923 and was grazed during the summer months from 1925 to 1932 by a small herd of cattle. Twelve hurdle plots 16 x 16 feet, supplemented by 12 quadrats were placed in this pasture to secure varying degrees of utilization of the important range plants each year. Field work was discontinued in 1932.

The data were summarized and analyzed during the past winter. Due to natural variations between quadrats and plots and due to the absence of replications, the present analysis does not permit drawing definite conclusions. A written report is on file.

4. The influence of season, frequency and degree of harvesting on the productivity and vigor of range vegetation

a. Empirical clipping phase.

Two grass species and one weed species were clipped under 16 systems of harvesting over the period 1923 to 1929 inclusive. Two browse species have been clipped under four methods of harvesting from 1926 to 1934 inclusive.

Analysis of the clipping data for the herbaceous species show that clipping at 1 inch from the soil line is very detrimental irrespective of time or frequency of the clipping. There seems to be a "shock" resulting from 1-inch clippings from which there is no apparent recovery. Two- and three-inch clippings indicate greater yield and better revegetation.

Analysis of the browse clipping data has not progressed far enough to draw any final conclusions. This work is being pushed to completion, however, and a report will be prepared as soon as possible.

b. Grazing phase.

A pasture study was initiated in 1923 to check results of former clipping trials on a pasture basis. Three 20-acre paddocks were used involving seven different grazing treatments. The paddocks were grazed by sheep from 1923 to 1929 inclusive. Field work ceased in 1930.

A partial progress report was completed during the past winter. Further analysis of this study will be made and a final report prepared.

c. Nutrition phase.

A study was initiated in 1931 in collaboration with Dr. E. C. McCarty, of Riverside Junior College, to determine the time and amount of carbohydrate food stored by two important grass species and one weed species under varying degrees and intensities of clipping. In addition, a study was made of plants under actual grazing practices.

Dr. McCarty has completed a report on the food march study and study of the effects of clipping was brought to a close in 1934.

The following results have been obtained:

1. Food storage in roots and stem bases is inversely related to the rate of growth of herbage.

2. Low carbohydrate values prevail in the roots during rapid production of herbage.

3. High carbohydrate content in roots follows the decline in herbage growth rate, near the close of the growing season.

4. Shoot growth begins 6 weeks to 2 months prior to the disappearance of snow.

5. Root growth and shoot growth alternate.

6. Food storage in roots is incomplete at seed maturity; therefore complete removal of herbage at this time results in diminished storage.

7. This study emphasizes the need for moderate use of the range, especially during the more active growing and storage periods. Enough herbage must be left to insure food storage and subsequent growth.

5. The determination of the influence of rodents on summer range lands with a view of exercising control for the improvement of the range

Until cooperation with the Biological Survey which was discontinued in 1931, is again established this subproject will remain inactive.

ARTIFICIAL RESEEDING (SUMMER RANGE)

The results of artificial reseeding trials on the Wasatch Plateau in central Utah from 1910 to 1927 were published in 1931 in Department Circular 178. All of the artificial reseeding trials made since 1925 have been centered in the oakbrush type. No new tests have been made since 1931. Recent field work has been directed toward

obtaining information on previous sowings. During 1934 all sowings were observed. These data were compiled during the past winter.

No new trials were contemplated for the coming field season. The information collected thus far on all artificial reseeding tests will be summarized in a progress report.

MANAGEMENT SAGEBRUSH-WHEATGRASS RANGE

Progress

I. U.S. Sheep Experiment Station Grazing Project
(Coop. U.S. B.A.I., Dubois, Idaho)

Four significant results have been derived as a result of past studies at the U.S. Sheep Experiment Station. These studies definitely show: (1) that climate is an important factor in the annual variation of forage production; (2) that overgrazing in the spring, regardless of whether grazing occurs early or late, is detrimental to the range; (3) that moderate or heavy grazing if carried on year after year at a fixed period in the spring is likewise detrimental to the range; and (4) that a portion of the spring forage growth must be left for fall grazing since summer and fall regrowth is uncertain.

Forage production varies from 60 percent above to 65 percent below normal in years of excessive or deficient moisture with two or more deficient years frequently occurring in succession. Any uniform rate of stocking designed to maintain the range, must be based on subnormal years since damage resulting from overgrazing in two or more successive deficient years may so change the plant cover that a lower normal of production is established. Such a basis would permit some forage waste during optimum and normal years but would result in full use during subnormal years. Utilization should be based on not more than 55 to 60 percent of the normal forage production.

Degree of deterioration on spring-fall range is closely related to the degree of spring utilization, with heaviest use resulting in the greatest deterioration. Paddock 1, for example with no spring use, but with heavy fall utilization shows no measurable deterioration except that which is due to climatic fluctuation; Paddock 2 grazed heavily throughout the spring season, has declined approximately 69 percent; Paddock 3, grazed lighter than Paddock 2 shows deterioration of approximately 50 percent; and Paddock 7, grazed moderately, shows only slight deterioration.

As proper spring grazing intensity is approached, rotation of use to avoid grazing during the same developmental stages, is essential. Paddock 7, grazed to an intensity of 11.9 sheep-days per acre during the spring shows some deterioration, whereas the main-herded range grazed to 10.5 sheep-days per acre under a system of rotated use has improved slightly.

On the basis of these results the present plan calls for studies in two major subdivisions:

I. Climatic Studies.

Subproject 1. Effect of climate on forage production

Variations in forage production as a result of adverse climatic conditions were portrayed clearly during the grazing season of 1934.

The 1933-34 fall and winter season was characterized by temperatures 4 to 14 degrees above a 10-year mean with practically no snow. The abnormality of the season was reflected in subsequent

plant development and forage yield. Grasses and weeds attained an average height of only 60 percent of normal, Balsamorhiza being the only herbaceous species to produce flower stalks. Density estimates indicated a 65 percent reduction in forage available and carrying capacity records show 60 percent less sheep feed units in 1934 than in 1933.

2. Grazing Studies.

Subproject 2. Rotation of spring grazing use

Eight 80-acre paddocks were set aside in 1933 to test the practicability of two grazing systems. One series of four paddocks is managed on a straight rotation and the other series on a rotation-deferred system during the spring grazing season.

Grazing early in the spring allows for an appreciable "catching-up" in utilization. Paddocks utilized in the spring to approximately 45 percent had, by the beginning of the fall grazing season, reduced utilization, as compared to ungrazed paddocks, to 25 percent. Ungrazed plants produced little or no growth following the end of the spring grazing season while plants grazed early in the spring with subsequent protection made a substantial recovery.

Subproject 3. Intensity of spring grazing use

Six 80-acre paddocks have been set aside for a study of intensity of use. Six intensities are to be used, namely; 6, 8, 10, 12, 14 and 16 sheep-days per acre. These paddocks will furnish valuable information leading to the establishment of proper spring grazing intensity for spring-fall range.

This subproject will not be initiated until relative carrying capacity figures can be secured on the paddocks included. The grazing season of 1935 will be devoted to securing dependable carrying capacity ratings.

Plant nutrition studies

Plant nutrition studies initiated during the fall of 1934 on the exclosures, on the eight paddocks devoted to the study of grazing systems and on Paddocks 1 and 2, fall and spring grazed respectively, will be continued. This study is being carried on in collaboration with Dr. E. C. McCarty. Chemical analyses are made at Riverside Junior College. The purpose is first, to determine the normal annual trend in food storage of bluebunch wheatgrass (Agropyron spicatum) and second, to study the effect of different periods and intensities of spring grazing on the nutrition of range grasses. The latter will aid in developing improved grazing systems. Results of analysis of 1934 collections indicate that fall grazing has but little effect on carbohydrate storage at the end of the fall season.

II. Induced Plant Succession - Fremont County, Idaho (Cooperation Fremont County Woolgrowers Association and State of Idaho

Data from 400 estimation plots, 56 quadrats and 56 brush plots on four sections of sagebrush range in Fremont County, Idaho burned over in 1933, are summarized briefly as follows:

The two drought years of 1933 and 1934 reduced the 1934 growth of all species on unburned plots to about 35 percent of that produced in 1932. Enough estimation plots were established for a

reliable comparative study of (1) unburned, (2) lightly burned, (3) moderately burned, and (4) heavily burned areas. Compared with unburned range, fire had little effect on lightly burned areas except that sagebrush was completely killed, whereas on the heavily burned wheatgrass (Agropyron dasystachyum) areas had increased 21 percent in density while Stipas had decreased. On the moderately burned quadrats a significant increase occurred in the total number of all grass plants, and in one individual species, wheatgrass. Basal areas of grasses were also increased significantly by moderate burning when compared with unburned quadrats. Wheatgrass and Koleria cristata showed significant individual increases. Moderate burning showed a tendency toward greater increase in basal area of grass than did the heavy burn. Soils of the heavily burned areas showed losses in organic matter, in total nitrogen, and in water-holding capacity and a gain in pH. A brief summary of the soil data is shown in the accompanying table.

The odds indicate that only heavy burns, in this case heavy enough to consume the large sage stumps, had any measurable effect on the soil. The surface soil from the area of the heavy burn, however, suffered a significant decrease in organic matter, in nitrogen, and consequently in water-holding capacity. The pH increased materially, probably due to the liberation of minerals from the plant tissues in the form of ash.

Effect of burning sagebrush by three intensities on soil qualities

Odds for gain (+) or loss (-)
When 20:1 is significant and 100:1 highly significant
(Fremont County, Idaho)

Class of burn: Vegetation Fraction	Organic Matter	Total Nitrogen	Water-holding	pH
Unburned	+ 1.07:1	+ 12.6:1	+ 95.2:1	0:1
Lightly burned	- 2.46:1	- 1.83:1	0:1	+ 9.9:1
Moderately burned	0:1	0:1	- 1.97:1	+2.86:1
Heavily burned	-4,999:1	-192.2:1	- 96.2:1	+65.2:1

Plans

1. Grazing studies at the U.S. Sheep Experiment Station will be conducted according to the approved cooperative grazing plan. Special studies capable of being completed within one season will be initiated if emergency funds become available.

2. Results of grazing studies previous to 1932 will be summarized in a technical report.

3. Two short articles describing a new method of mapping browse and noting improvements on the Hill chartograph will be prepared.

4. A key to the identification of native grasses at the Sheep Station using vegetative characters will be prepared for publication.

5. The effect of drought on vegetation of sagebrush-wheatgrass range will be summarized in a technical report.

6. Observations will be continued on range utilization, concentrating efforts toward securing palatability ratings on spring-fall range forage species.

7. Clipping studies, plant development studies and vegetative inventories and plant nutrition studies will be continued.

8. All plots, quadrats, etc. will be rechecked at the Fremont County Burning area to note the comparative effect of climate and moderate grazing on burned and unburned sagebrush range. Soil moisture samples and phenological measurements will be taken on burned and unburned sites.

9. A technical article will be written on the effects of burning sagebrush on the soil and vegetation of sagebrush-wheatgrass range.

MANAGEMENT OF DESERT SHRUB RANGE

Emergency funds have made possible a considerable enlargement of grazing studies on the desert shrub winter ranges of Utah and Nevada. While the experimental pastures and range allotments are being fenced and made ready for controlled grazing tests, surveys concerning several aspects of the volume and condition of the plant cover have been prosecuted. These surveys have yielded most of the data reported under various subsequent headings.

Progress

1. Palatability of desert vegetation

The palatability of important forage species near the Desert Branch Station has been determined by observing the degree of utilization soon after grazing by livestock. Several thousand observations were made by following the animals as they grazed and estimating utilization of individual species. In general, palatability proved similar to previous observations on other ranges but differed sharply in a few respects. A list of the most abundant species together with their estimated palatability follows:

Grasses	Palatability	Weeds	Palatability
Aristida fendleriana	30	Salsola	30
Bouteloua gracilis	40	Sphaeralcea grossulariaefolia	50
Hilaria jamesii	40	Aplopappus nanus	0
Oryzopsis hymenoides	85		
Poa nevadensis	85		
Poa secunda (sandbergii)	65	Browse	
Sitanion jubatum	90		
Sporobolus contractus	60	Artemisia nova	80

Browse (cont.)	Palatability	Browse	Palatability
Artemisia spinescens	85	Grayia spinosa	80
Artemisia tridentata	20	Gutierrezia sarothrae	15
Atriplex canescens	60	Juniperus utahensis	5
Atriplex confertifolia	25	Kochia vestita	10
Cercocarpus intricatus	60	Polygala subspinosa	0
Chrysothamnus nauseosus	0	Sarcobatus vermiculatus	10
Chrysothamnus stenophyllus	10	Symphoricarpos longiflorus	0
Ephedra nevadensis	70	Tetradymia glabrata	10
Eurotia lanata	65		
Forsellesia spinescens	20		

2. Survey of plant cover and forage values on spring-fall and winter ranges

Data obtained in the 1932-33 survey of the spring-fall and winter ranges show the degree of deterioration in the volume of plant cover and in the forage value. Small protected areas formed a basis of comparison with similar ranges exposed to unrestricted grazing. A summary of the data is as follows:

Area	Class of Range	No. of Plots	Percentage Deterioration	
			Plant Cover	Forage Value
Owyhee County, Idaho	Spring-fall	440	35.9	76.0
Elko County, Nevada	do.	181	18.3	79.0
Snake Rv.Plains,Idaho	do.	231	39.6	74.9
Salt Lake Valley,Utah	do.	57*	30.9	79.1
Sevier Valley, Utah	do.	79*	32.4	69.4
Colo.Rv.Drainage,Utah	do.	44*	32.2	52.7
West Desert, Utah	Winter	672	45.0	64.1
Nevada Desert	do.	283	22.3	51.4
Nevada Foothills	do.	182	35.0	79.1

*Large plots by old reconnaissance method.

3. Replacement of palatable forage species by less palatable ones

In certain localities, some of considerable extent, covered by the 1932 and 1933 surveys, the density of vegetation on grazed range equalled that on protected areas. Eight of these areas were studied in sufficient detail to show that there had been a general replacement of the palatable forage by species of low palatability, these replacements maintaining and on three areas actually increasing, the density of the plant cover. The forage value of these areas, however, averaged only 31 percent as much as that which existed on protected range. This substitution of unpalatable plants for palatable forage species, while not readily apparent, has caused marked range deterioration.

The principal changes in species composition on the spring-fall ranges were heavy losses of perennial grasses and great increases of unpalatable weeds and shrubs, including an enormous increase in sagebrush. On the winter ranges, grasses and valuable forage shrubs were greatly diminished in volume and rabbitbrush (Chrysothamnus stenophyllus) was greatly multiplied, sometimes by several hundred percent.

4. Mortality and reproduction of desert forages

Palatable shrubs on a winter range area near the Desert Branch Station, grazed only when snow is available, have suffered an average mortality of about 20 percent during the recent drought period. On a range nearly comparable, except that it is accessible to water and has been heavily grazed for many years, the average mortality has been about 67 percent. As shown in the accompanying table the palatable species suffered to the greatest extent.

Comparisom of the percentages of mortality resulting from 3 years of drought combined with light and heavy grazing

Species	Palatability	Degree of Grazing	
		Light	Heavy
		%	%
Oryzopsis hymenoides	High	24	89
Eurotia lanata	High	11	67
Atriplex confertifolia	Medium	28	33
Chrysothamnus stenophyllus	Very low	10	7

An additional note of interest is suggested by the above table in that mortality attributed to drought alone does not appear to have been excessive as only from 10 to 28 percent of the plants died from drought and light grazing combined. On the other hand, a combination of heavy grazing and drought have caused losses as high as 89 percent.

5. Lack of reproduction of valuable forage plants

Almost complete absence of young plants of species highly palatable to livestock is a wide-spread condition on open winter ranges. Initial counts on a series of 10 plots, each 100 square feet in size, taken at intervals of one half mile on typically grazed range in southwestern Wyoming, showed only six young plants of valuable forage species and 99 young weeds and shrubs which are practically useless for forage. Another such count on winter range in Wah Wah Valley, Beaver County, Utah showed no young grass plants or other valuable forage species on 15 randomized plots. On these same plots, however, 65 young plants of the unpalatable species of rabbitbrush were found. Whether there had been no germination or whether young plants of palatable species were killed after germination was not established by this study.

Near the Desert Branch Station one area showed only 7 percent of the highly palatable white sage (Eurotia lanata) with less than 21 vascular rings and practically none with less than 10 rings. On the other hand, 91 percent of the unpalatable rabbitbrush had a ring count of less than 21, and 45 percent of it has a ring count of less than 10. These ring counts indicate clearly that the palatable species are not reproducing and that they are being gradually replaced by unpalatable species. It is possible and highly probable that virtual extinction of all desirable forage plants will result unless severe overgrazing is stopped.

6. Forage destruction near watering places

Desert range surrounding a well which has been furnishing water for 8 years and which is 12 miles from other permanent water, was found to be seriously deteriorated. Within a radius of 3 miles grass and palatable shrubs decreased rapidly as the well was approached. Only 4.3 percent as much grass and 20 percent as much total forage was formed in the 1,000-foot zone adjacent to the well as in the 15,000-foot zone where livestock concentration was greatly lessened. In another locality, range which had been heavily used for 40 years and depleted 65 percent from its original condition was found to have a forage value only 24 percent as great within a radius of 1,000 feet from a permanent water hole as within a radius of 12,000 feet.

7. Vegetation changes on drained mountain meadows

Mountain Meadows in Washington County, Utah, before 1885 was noted for its abundant grass, sedge, and rush (Juncus) plant cover. About 50 years ago the meadows were drained by the headward lengthening of gullies into the mountain valley. The area, still heavily grazed, is now almost fully occupied by junipers and large sagebrush 4 to 7 feet tall. The sagebrush is nearly all under 40 years of age. Grass, abundant in a fenced portion of the meadow, is almost lacking on the open range. Furthermore, there is little sage in the fenced area, the grass apparently excluding it.

Bottomland formerly in wet meadows is now populated with junipers 10 to 40 years old and sage that is nearly all under 10 years of age. From the meadows to the foothills there is a gradual gradation of age classes of both juniper and sage indicating the invasion of the meadows by these species and loss of grazing capacity.

8. Nevada range and fenced railroad right-of-way survey

A survey of plant cover conditions inside and outside the fenced Southern Pacific railroad right-of-way has shown that vegetative changes of major importance have taken place in northeastern Nevada foothills and desert ranges during the last 30 years. The 1,540 plots established for the purpose of this study can be classified into four groups: (1) desert shrub foothills, 240 plots; (2) sagebrush-wheatgrass hills, 470 plots; (3) sagebrush-Elymus valley edges, 510 plots; and (4) desert shrub valley lands, 320 plots.

In the 30 miles of desert shrub foothills, Oryzopsis hymenoides, Sitanion hystrix, and Eurotia lanata show decreases on the outside grazed range of 64, 71, and 71 percent respectively.

The 40 miles of desert valley zone exemplified another typical desert condition. Black sage (Artemisia nova) a highly palatable and therefore heavily grazed shrub, shows a 28 percent decrease outside the protected right-of-way. Shadscale (Atriplex confertifolia) however, protected against unduly heavy grazing by strong sharp spines, which frequently preserve enough foliage to keep it vigorous, has actually gained 37 percent on grazed range, probably by occupying space left by the decrease in black sage and other palatable species.

In the 40 miles of sagebrush-wheatgrass hills, Agropyron smithii, Elymus condensatus, and Sitanion hystrix have decreased 43, 97, and 80 percent respectively on the outside heavily grazed range.

On the 70 to 80 miles of sagebrush-Elymus valley edges in the Humboldt River Valley, giant wild rye (Elymus condensatus) is almost the exclusive native forage. Outside the right-of-way there is 78 percent less Elymus, but 111 percent more rabbitbrush (Chrysothamnus). The number of rabbitbrush plants is nearly as great inside the right-of-way as on the outside, but the volume of growth is somewhat less than half as great. Suppression of rabbitbrush by Elymus is so severe that 50 to 75 percent of the crowns of many of the plants are dead.

Plant cover for the entire survey showed a 10-percent decrease in average volume and a 51.8 percent decrease in forage value on the open range. A summary of the data for all the vegetation appears in the following table.

Average volume of plant cover and average forage value inside and outside fenced railroad right-of-way for all species, using the growth inside as a base. Nevada, 1934.

Class of Vegetation	Percent change based on protected vegetation	
	Plant Cover	Forage Value
Grasses	-56.8	-67.8
Shrubs	+13.2	- 3.3
Weeds	-38.4	-40.2
All vegetation	-10.0	-51.8

9. Nutrition study of sheep (In cooperation with the Utah State Agricultural College)

Three bands of sheep were grazed on the desert shrub winter range in 1934. One was given corn as supplemental feed, one was given cottonseed cake, and one was given no supplemental feed. The sheep in these bands were compared as to changes in live body weight and wool yield. The first year of trial has shown little difference in body weight or in wool yield.

Forage samples of the principal plant species on this range were collected each month in connection with the nutritional phase of the study. These samples are to be analyzed for nutritive value by the Utah State Agricultural College.

10. Herd studies

Herd studies on the Desert Branch experimental range, including information on annual migrations, grazing history, and management, were continued on the basis of records obtained during the winter of 1933-34.

11. New methods of range surveying by small sample plots

A new method of range survey thought to be superior to the old reconnaissance method, especially for intensive survey of an experimental tract, has been developed in the Intermountain Station.

For sometime it has been apparent that for range study plots varying from one acre up to several thousand acres a more accurate method of estimating the vegetative cover is needed. Accordingly a method was devised which is a modified adaptation of the forest survey plot method. Instead of selecting and examining a large area of "representative" range and reporting its average density, small plots of either 100 or of 200 square feet are established at mechanical intervals and the number of square feet of plant cover for each major species is recorded down to one half or one quarter of a square foot. These estimates summed give the total volume of plant cover by species on each plot. Such observations have been found to resemble quadrat data more closely than reconnaissance estimates.

It has also been found that several persons can separately obtain the same figure within a reasonable limit of error because they examine an area small enough to be seen definitely and can so visualize the vegetation that the estimate approaches a "measurement" much more nearly than when a large area is used as a unit. Replication of plots by this system also permits a statistical analysis of reliability. In experimental work statistical analysis has proved valuable, but perhaps in ordinary range survey this phase could be omitted entirely.

Studies have been made of several blocks of land at widely separated localities, each block consisting of four sections with 100 plots to the section. All of the 400 plots were considered as a composite estimate, then one half, one fourth, one eighth and one sixteenth of the plots. The coefficient of variability was calculated for each plot grouping. At the U. S. Sheep Experiment Station at Dubois, Idaho, 25 plots, or approximately six plots per square mile, gave a close approximation of the volume of plant cover to that shown by 400 plots. This was likewise true on the desert range, and also on the Davis County watershed.

Plans

The plans for 1935 are summarized briefly as follows:

1. Analyze and prepare manuscripts on all completed projects.

2. Prepare grazing plan for the Desert Branch Experimental Range. A tentative outline of a proposed plan included herewith is to be considered during the next few months by a number of individuals interested in grazing experimentation and administration in order to revise and prepare details of a plan to begin actual grazing about November, 1935.

3. Continue cooperative nutrition studies with Utah Agricultural Experiment Station as shown under III in following tentative outline.

4. Continue plant growth and plant development records.

5. Continue palatability and utilization studies of desert shrub vegetation.

6. Complete the open and enclosed plot system on the Desert experimental range.

7. Complete analysis of vegetative survey on Southern Pacific railroad right-of-way in Nevada. This will be checked on the ground and a report written.

8. Continue frequency studies of desert species begun in 1934.

9. Continue study of relationship of desert soils to the distribution of desert vegetation. Check on the ground the data taken during 1934 and extend to other areas.

10. Explore the possibility of making forage inventories as a guide to winter grazing.

Tentative outline of experimental grazing treatments at Desert Branch

Experimental range

I. Pasture grazing.

A. Intensity of grazing.

1. Light grazing.

2. Normal grazing.

3. Heavy grazing.

B. Seasonal use.

1. Winter only.

2. Winter and spring.

3. Fall and winter.

II. Range grazing.

A. Seasonal use.

1. Winter only.

2. Winter and spring.

3. Fall, winter and spring.

B. Deferred use.

1. Rest one season.

2-4. Grazed by periods.

C. Compact vs. open herding.

D. Manner of utilization.

Full use in one grazing vs. several partial grazings.

III. Supplemental feeds and mineral nutrition of sheep (cooperation with Animal Husbandry and Range Management Departments of Utah State Agricultural College).

A. Herd studies.

1. Corn.

2. Cottonseed cake.

3. Check.

B. Pasture Studies.

1. Corn.

2. Cottonseed cake.

3. Mineral supplement.

4. Check, blood tests of animals.

EROSION - STREAMFLOW INVESTIGATIONS

Erosion-streamflow investigations during the past year can be segregated most logically under the following headings: studies of the problems on the Boise River watershed, continuation of observations and records on erosion areas A and B at the Great Basin Branch Station, expansion of erosion control work at the Wasatch Branch Station, completion of a geological report on erosion in the Colorado River drainage, and development of plans for an enlarged program of forest and range influence research for the Intermountain Region as a whole.

BOISE EROSION

1. Streamflow analysis

Preliminary analysis of rather incomplete Boise River streamflow and climatic data in 1930 indicated a trend in recent years toward decreased water yield and a tendency for spring runoff to reach an accentuated peak at increasingly early dates. During the past year an effort has been made to compile the streamflow and climatic data in a more usable form than was done in 1930 and make a critical analysis of the relationships existing between streamflow, precipitation, and temperature.

This compilation has progressed sufficiently to reveal very high correlations between precipitation at various weather stations and the Boise River streamflow. Moreover, the analysis

thus far substantiates the earlier studies with respect to a trend toward decreased water yields in recent years. For example, as is shown in the summary table, precipitation, for the period 1895 to 1934, declined 11.8 percent while streamflow, during the same period, declined 18.6 percent below the long-time mean. In more recent periods, 1910 to 1934 and 1922 to 1934, both precipitation and streamflow declined still further, but as can be noted in the table, streamflow has shown a consistently greater decrease than precipitation. The accentuated decrease in streamflow is particularly evident during the last 12-year period. The data derived from this study do show, however, that there is regression of precipitation and streamflow for the periods studied, and it is suggested that total run-off even in abnormally dry years is equivalent to a given percentage of precipitation.

The comparative regression of precipitation at Boise and streamflow of Boise River in terms of percent decrease from mean during different periods of years between 1895 and 1934.

Periods	1895 - 1934	1910 - 1934	1922 - 1934
Boise Precipitation	11.80	20.50	22.05
Boise River Run-off	18.60	29.54	35.70

For the future it is planned to refine the analysis of the various records and determine the relationship between climate and streamflow more accurately, as well as ascertain the degree of correlation existing between climate and date and height of peak flow in the spring, and date and height of low flow in the summer.

2. Snow surveys

The three snow survey courses on the headwaters of the North, Middle and South Forks of Boise River are continuing to yield valuable information to the water users in Boise Valley. For example, during the very dry year of 1934, measurement of the water storage in the snow mantle in advance of the irrigation season made it possible to predict a 50 percent deficiency in water yield. The information was most helpful in arriving at an equitable distribution of the limited water supply.

3. Run-off and erosion studies with portable equipment

Two complete units of portable erosion apparatus manned by a crew of five men were used during the 1934 field season to obtain run-off and erosion data from 96 temporary 1/200-acre plots. A composite description of the study plots is contained in the following table.

Slope	Precipitation 1/	Soil 2/	Vegetative Type			
			Annual weed	Cheat-grass	Stipa - Lupine	Agropyron
30%	Low	U	3 plots	3 plots	3 plots	3 plots
		D	3 "	3 "	3 "	3 "
	High	U	3 "	3 "	3 "	3 "
		D	3 "	3 "	3 "	3 "
40%	Low	U	3 "	3 "	3 "	3 "
		D	3 "	3 "	3 "	3 "
	High	U	3 "	3 "	3 "	3 "
		D	3 "	3 "	3 "	3 "

1/ Precipitation
Low = 0.03 in. per min. for 60 min. = 1.80 inches.
High= 0.06 " " " " 30 " = 1.80 "

2/ Soil
U = Undisturbed and in natural state.
D = Surface inch thoroughly disturbed by trampling.

Analysis of the run-off and erosion data from these plots was complicated because of the uncontrolled soil heterogeneity encountered in the 40 percent slope class. In spite of this difficulty, however, the following significant results were obtained by means of analysis of variance.

Groups of plots compared	Percent of rainfall which ran off	Ounces of silt removed per plot
All 30% Annual weed plots	56.0	383.2
" " Cheatgrass "	12.2	45.0
" " Stipa-Lupine "	65.1	168.8
" " Agropyron "	37.4	98.5
" " Undisturbed soils	38.7	115.05
" " Disturbed "	46.7	232.3
" " Low intensity precip.	(no significant	542.2
" " High " "	difference)	848.3
All Annual weed & cheatgrass on 30% slopes	34.1	214.9
All Annual weed & cheatgrass on 40% slopes	52.2	

The analysis of the data collected thus far indicates that vegetative type was the most influential of the variables studied in affecting run-off and erosion. From an erosion control standpoint the annual weed and Stipa-Lupine types are distinctly less desirable than the cheatgrass (Bromus tectorum) and Agropyron types. Of the two latter, for the conditions of the experiment at least, the cheatgrass is superior. There is some indication, however, that had the slopes been steeper and longer, the cheatgrass would have suffered severe gullying and yielded much more run-off and erosion than the more stable Agropyron type would have done under the same conditions.

In general, the disturbed soils yielded significantly more run-off and nearly twice as much eroded matter as did the soils in their natural state. Under certain conditions, however, when run-off was very slight, soil disturbance favored absorption of precipitation and thus reduced run-off and erosion very effectively.

The significant influence of precipitation intensity and steepness of slope on run-off and erosion in those types where the soil was homogeneous enough to warrant comparisons is well marked and indicates the importance of these variables in any comprehensive study of this kind.

In addition to providing preliminary data on run-off and erosion this study has served to emphasize the need of accurate control aswell as thorough consideration of all influencing factors in any erosion-streamflow problem. The highly variable results obtained indicate that all studies where a number of complex interacting variables may be acting should be based on a large number of either permanent or temporary plots if reliable conclusions are to be drawn.

4. Quadrat and plot study

All of the 104 meter quadrats and the 98 major plots on the Boise River watershed were remeasured during the past field season, and the changes in plant density and composition which have occurred since the inception of the experiment in 1930 and 1931 were ascertained. A summary of the results of the analysis of these plots is presented in the following table:

Class of Vegetation	Percent Change 1930 to 1934	
	Protected	Grazed
Total Density	-33	-56
Perennial Grass Density	+ 18	-18
Perennial Weed Density	-20	-34

The effect of drought during the last four years is plainly marked by the significant decrease in all classes of vegetation except the protected perennial grasses, which increased significantly. From 1931 to 1934 drought resulted in a decrease of over 90 percent in the annual weeds and a decrease of 20 to 34 percent in the perennial weeds. In spite of the extremely dry conditions, perennial grasses were able to increase under protection, definitely indicating that these grasses are the most stable range vegetation during periods of adverse climatic conditions.

Under protection good stands of bunchgrass (Agropyron inerme) decreased slightly in density, doubtless owing to the effects of drought. In depleted stands, however, increases in density up to 250 percent occurred and this resulted in an average increase of 41 percent for the bunchgrass class as a whole. In contrast grazed plots of this same species of grass showed a decrease of 35 percent in total density.

Numerous bunchgrass clumps which were nearly dead and producing very little forage in 1931, were observed to have regained their vigor after three years of complete protection and are now producing considerable forage. New seedlings were very scarce even under protection, the increase in density of bunchgrass being attributed almost entirely to the increase in the size of plants present in 1931. From these studies it appears that reestablishment of the original perennial grass cover is the most effective means of stabilizing forage production during drought years.

5. Root studies

Further excavation of the roots of important herbaceous species on a variety of sites on the Boise River watershed has shown that each species has a relatively constant type of a root system which may be considered as a species characteristic. The greatest variation for a given species was found between individuals growing on north and on south slopes. On the basis of the present root studies range plants can be grouped into four classes as follows:

1. Fibrous rooted species -- Agropyron inerme, Poa secunda, Carex geyerii, Koeleria cristata, Bromus tectorum.
2. Semi-fibrous rooted species -- Achillea lanulosa, Hieraceum griseum, Anaphalis spp., Pentstemon humilis, Vicia americana.
3. Fibro-tap rooted species -- Geranium viscosissimum, Balsamorhiza sagittata, Peonia brownia, Eriogonum spp., Lupinus spp., Astragalus spp., Lithospermum pilosum.

4. Tap-rooted species -- Crepis acuminata, Agoseris pumila, Gayophytum diffusum, G. ramosissimum, Lactuca scariola, Collomia linearis.

From an erosion control standpoint the most desirable species appear to be those included in the first two classes. Fortunately these same species are the most valuable forage plants and can be favored by the application of proper range management practices.

The soil-holding ability of the plant community as a unit has been studied by means of bisects through the important vegetative types of the watershed. Comparison of these bisects indicates that the depleted types are of much less value in erosion control than the original climax community and that the prevailing accelerated erosion in the depleted types may be attributed in large part to the absence of species with fibrous root systems.

6. Installations

Duplicate range watershed areas of 11 acres each in the Boise Basin Experimental Forest near Idaho City were fenced and equipped with run-off and erosion measuring devices during the summer of 1934. The installation is similar to the set-up on the A and B erosion areas at the Great Basin Branch Station in Utah, except for two refinements. A silt sampler has been attached to the 90° weir on the surface run-off settling basin to measure silt that passes over the outlet, and the cut-off wall was grouted into bedrock and equipped with a drain so that seepage flow may be

measured separately from the surface run-off. Thus far the only run-off has been from melting snow and it has been mostly in the form of seepage flow--probably owing to the fact that the soil was so dry last fall that most of the water has been retained on the watershed, and because settling occurred in the backfill behind the cut-off well, permitting much of the surface run-off to percolate to the seepage drain. The settling of the soil behind the cut-off wall during the current winter and artificial puddling and raising of the ground level to the lip of the surface run-off flume during the coming summer should remedy the surface flow "leak" in subsequent years.

A battery of six 2-milacre lysimeters was installed near the duplicate watershed areas to measure the consumption of water by individual species of range plants on a yearlong basis. The tanks, which are about 8 feet wide, 11 feet long, and 4 feet deep, and on a 30 percent slope, were electrically welded in place on a common concrete slab and filled with a known volume of soil that was excavated by one-foot layers from the site. In order to permit maximum freedom of seepage flow from the base of the 4-foot soil profile, a 6-inch-wide section across the lower end of the tank was extended 18 inches below bottom of the lysimeter and filled with coarse sand and gravel. The seepage drain was taken out at the base of this gravel column. It is planned to install a cellar-type gauge shelter at the base of the lysimeter battery,

equipped with multiple point float gauges for measuring seepage and surface run-off. It is planned to install a duplicate battery on a nearby site, and to set up a battery of lysiphytometers to measure current consumption of water by the same species that are planted in the lysimeters.

GREAT BASIN EROSION

Wasatch Branch

1. Flood damage survey

A survey of the area in Davis County, Utah, which is subject to flooding was completed in the fall of 1934. The survey revealed the need for a revaluation of so-called range lands in terms of watershed protection values. It was found that during the past 10 years this highly developed valley area consisting of about 5,120 acres and valued at about $6,000,000 has suffered a $1,000,000 damage loss from floods that originated as a result of past overgrazing and fire on an adjacent mountainous watershed unit of 18,560 acres which has been valued for private use at only about $40,000, or a little more than $2.00 per acre. By means of a detailed compilation of the damage that occurred from the floods on the 1,833 acres of inundated valley land, it has been determined that the former protective and water supply value of the flooding canyons was not less than $75.00 per acre. If the losses are charged against the catchment basins of specific canyons from which the floods originated, watershed values as high as $654.00 per acre are justified.

The residents of Davis County are thoroughly aroused over the losses they have suffered and are actively urging that the watershed unit be placed under the control of a governmental agency. It has been pointed out to them that all of the critical lands on the watershed unit could be purchased by taxing themselves only $7.40 per $1,000 of assessed values of valley property, or a yearly tax of only 74 cents per $1,000 of taxable assets for a period of 10 years. The town of Centerville followed such a procedure several years ago and thus gained control of grazing on the headwaters of Centerville Canyon. Although this canyon adjoins the six flood canyons that caused so much damage to the town of Farmington and other communities, no floods have occurred out of it.

A more detailed report of this survey is expected to be published in the Geographical Review during the summer.

2. Plant density and floods

An intensive erosion-plant density survey was made on the Davis County watershed area in 1934. A summary of the results of this survey, based on a statistical analysis of field data obtained from 442 sample plots taken at 2-chain intervals on contour transects in the headwaters of six canyons, is presented in the accompanying table.

The relation of plant density and four cover types to the occurrence of four degrees of erosion on the Davis County, Utah watershed

Erosion Class	COVER TYPE							
	Weed (53)*		Sagebrush(85)*		Browse (188)*		Aspen (116)*	
	Mean Vegeta. Density	Plot Occurrence	Mean Vegeta. Density	Plot Occurrence	Mean Vegeta. Density	Plot Occurrence	Mean Vegeta. Density	Plot Occurrence
		%		%		%		%
No erosion	.210	1.9	.205	5.9	.266	24.4	.134	23.3
Light erosion	.074	3.8	.130	37.6	.153	46.3	.83	44.8
Moderate erosion	.023	39.6	.092	29.4	.087	13.8	.041	19.8
Serious erosion	1.011	54.7	.042	27.1	.043	15.4	.025	12.1

* Number of plots

This survey definitely substantiates the conclusions reached by Bailey, Forsling and Becraft in USDA Miscellaneous Publication 196 "Floods and Accelerated Erosion in Northern Utah" wherein they pointed out that a reduction in the plant cover on critical portions of the watersheds by past overgrazing and fire was an important contributing factor to the recent occurrence of floods. It can be noted, for example, that the degree of erosion observed on the sample plots increased inversely with the density of the plant cover. Moreover, there was relatively more erosion on areas supporting a weed type of plant cover than on areas supporting vegetation having more extensive root and branch habits, such as is typical of the sagebrush, mixed brush, and aspen, although erosion may reach serious proportions on lands with the latter kinds of cover if the density of the vegetation is appreciably reduced.

3. Soil studies

In connection with the survey of plant density in relation to the four classes of erosion, as reported above, a soil survey was undertaken during the 1934 season to determine some of the physical and chemical characteristics of the soil horizons on this area and to lay a foundation for long-time studies of soil rehabilitation. About 140 soil samples have been collected but as yet the laboratory analyses have not been completed.

4. The terrace-trench system of erosion control

One of the most spectacular enterprises of the station during 1934 was the planning and technical direction of erosion control work on the steep slopes of the Davis County watershed area. The system of erosion control used involved the construction of 65 miles of shallow trough-like terraces along the contour of eroding slopes on the watershed. The terraces were spaced at intervals of about 25 feet, with shoulders on the downhill side high enough to form a trench which will hold all of the precipitation and run-off expected on the area during a 1.5-inch storm. Various species of cultivated grasses, as well as numerous native weeds and grasses were sown on a total of 245 acres of terraced and contiguous denuded areas and in addition 45,000 Douglas fir transplants were planted on the terraces during the spring of 1935. The artificial reseeding and planting on the terraced areas is considered to be highly essential to the continued effectiveness of the control system.

This system of control was applied on 228.9 acres of watershed land in the headwaters of three of the flooding canyons in the Davis County area. The estimated cost of work was $11,664.74, exclusive of reseeding. The cost of control per acre, varied from $26.51 for terraces constructed by power equipment to $116.74 for hand construction. Although such an investment seems exhorbitant for land that is ordinarily worth only $2.00 per acre, the cost is fully justified when it is considered that floods which originated from these three drainages caused damage to property at the mouths of the canyons amounting to $296,151.00.

The effectiveness of the system for controlling run-off was tested during the summer when a storm of .5 inch of rain occurred over an area on which the terrace system was only partially completed. No run-off occurred from the terraced slopes, whereas on the unterraced area sufficient run-off accumulated in the drainage channels to cut old gullies a foot deeper, and to carry boulders 9 feet in diameter out of the mouth of the canyon. It is planned to extend this system of control over other critical parts of the watershed during the coming year.

A description of this system of erosion control appeared in the March issue of American Forests under the title of "Shackling the Mountain Flood."

5. Run-off plot installations

During the summer of 1934, four 1/10-acre and twelve 1/40-acre plots were installed on the Davis County area to measure surface run-off on a year-long basis. The larger plots were situated in aspen while the smaller ones were confined to areas supporting a cover of weeds. Two slopes were represented.

Great Basin Branch

Erosion Areas A & B

Beginning with fall grazing in 1934, a new plan of management was inaugurated on Areas A and B as a check on the original set-up of this long-time experiment. Originally, Area A was denuded to a 16 percent ground cover of vegetation and then allowed to improve to a 40 percent ground cover, while Area B was maintained at 40 percent. The new plan calls for a reversal of this arrangement, or the denudation of Area B while Area A is maintained at the present level.

An analysis has just been completed of the run-off and erosion records from Areas A and B for the last 5-year period (1929-1934), during which time the plant density on both watersheds has been maintained at approximately 40 percent. These data substantiate conclusions reached by Forsling following a comparable 5-year period ending in 1929, to the effect that, under the conditions of the experiment, melting snow is not an important erosive agent; the quantity of sediment eroded is proportional to the

volume of run-off; relatively more run-off occurs on Area A than B; and that more run- off is required to produce the same amount of erosion on Area B than on Area A.

Run-off Plot installations

Six surface run-off plots of 1/40-acre each were installed in Ephraim Canyon during the past year. Three of the plots were established in the weed-grass association at an elevation of about 9,000 feet while the other three were established in the oak-sagebrush zone at an elevation of about 6,500 feet. Run-off records from melting snow are being obtained during the spring of 1935.

COLORADO RIVER EROSION

1. Epicycles of erosion

By means of physiographical and geological observations in a number of watersheds tributary to the Colorado River additional evidence has been gathered regarding the comparison of the role played by vegetation in controlling erosion to other forces affecting erosion such as diastrophism and climatic change. The fact that erosion has been progressing at a relatively rapid rate throughout the Colorado Plateau province, is generally well known. Where plant cover has played no part in the erosional processes, such as in Bryce Canyon and the Chinle area, however, examination of the canyon walls and valley bottoms revealed no evidence of a recent acceleration in the normal rate of erosion. If there had been a sufficiently

great change in climate, or if diastrophism had occurred, either of these changes would have caused an acceleration in the rate of erosion on these areas. As a matter of fact, the only areas that are now eroding at an excessive rate are those on which there has been an abrupt change in the vegetative cover. In all cases where serious erosion was found to be occurring, such as in Kanab Creek, Johnson Wash and other areas in southern Utah, the beginning of accelerated erosion was traced directly to the use of the valley lands and mountain slopes by man or his domestic animals.

The results of these observations were reported at the winter meeting of the A.A.A.S. and have been published in the May-June issue of the Journal of Geology.

Plans

Forest and range influence studies for 1935-36 hinge largely on the availability of sufficient emergency funds with which to continue and expand going projects and to initiate essential new work, both phases of which necessarily involve a considerable amount of construction and the development and installation of special instrumentation. Tentatively, the maximum program includes (1) the continuation and expansion of work on the range-covered granitic soils and the initiation of studies on timbered areas on the Boise River watershed in Idaho; (2) continuation of range influence studies on the Wasatch Plateau, expansion of erosion control measures and water yield studies on

the steep slopes of the Wasatch front, and initiation of wind erosion studies in the desert valleys of Utah; and (3) continuation of observational studies and initiation of intensive investigations of run-off and erosion on the sedimentary formations of the upper basin of the Colorado River.

Some phases of the program overlap subproject centers of work within the major provinces or are of such a nature that they can be completed in a relatively short time. These are listed below as special studies, as compared to more comprehensive long-time investigations which follow.

SPECIAL STUDIES

1. Watershed - Community Relationship Surveys: To determine the relative value of the water, range, timber and other forest resources in relation to dependent communities. Proposed study areas include:

   (a) Boise River watershed - Boise Valley

   (b) Davis County watershed - Davis County Valley strip

   (c) Upper Colorado River Basin - Lower Basin

2. Climate and Streamflow Relationship Studies: To determine the degree of correlation between recent climatic fluctuations and variations in annual streamflow, height and date of peak flow, and height and date of low flow. Proposed data to be compiled and analyzed include:

   (a) Boise and Boise Basin weather records, and Boise River streamflow data.

(b) Salt Lake City and other Utah weather records, and Salt Lake City and other Utah river streamflow records.

(c) Colorado Basin weather records and Colorado River streamflow data.

3. Physiographic relationship studies: To trace the history of mudflows from the Wasatch front and to evaluate the physical factors which contribute to soil formation or which have a bearing on soil erosion and erosion control methods.

4. Hydrological studies: To develop a flume for measuring heavily laden streamflow on steep gradients.

LONG-TIME STUDIES

I. Granitic Soils, Idaho

A. Boise range influences.

1. To determine the influence of grazing and trampling by livestock on water yield and erosion. One phase of this study is to be conducted on comparable, complex watersheds, while other phases such as the influence of different intensities of grazing and different methods of erosion control, are to be studied on comparable, run-off areas.

2. To determine the effectiveness of present associations of range plants for regulating run-off and erosion under controlled conditions of slope, soil and artificial rainfall, by means of portable apparatus.

3. To determine water losses through transpiration and consumption of range plants by means of lysimeter and lysiphytometer studies.

B. Ponderosa pine influences (new).

1. To determine the influence of different methods of cutting on water yield and erosion. The effect of cutting to be studied on the basis of comparable, complex watersheds while other phases, such as the influence of different age classes and associations of species on water yield and erosion, are to be studied on comparable run-off areas.

2. To determine the effectiveness of litter cover and understory vegetation on surface run-off and erosion induced by summer storms under controlled condition of slope and intensities of artificial rainfall by means of portable apparatus.

3. To determine water losses through evaporation, interception, transpiration and consumption of forest understory species by means of lysimeters and lysiphytometers.

II. Great Basin, Utah

A. Wasatch Plateau summer range influences.

1. To determine the influence of herbaceous vegetation of controlled density for regulating run-off and erosion, by means of paired watersheds (A & B).

2. To determine the influence of typical range plant associations on year-long water yield and erosion, by means of permanent run-off plots.

3. To determine the effectiveness of the present range cover on a variety of typical sites for regulating run-off and erosion induced by summer storms, by means of portable apparatus.

B. Wasatch front brush range influences.

1. To determine the influence of grazing and the effectiveness of different systems of erosion control on water yield and erosion by means of studies on complex watersheds and run-off areas.

2. To determine the influence of typical plant associations on year-long water yield and erosion by means of run-off plots.

3. To determine water losses through evaporation, transpirations and consumption from and by typical species in lysimeters and lysiphytometers.

C. Desert valley range influences (new).

1. To determine the effectiveness of desert shrub vegetation for controlling torrential run-off and wind erosion, by means of permanent plot studies and tests with portable wind apparatus.

III. Colorado River, Utah

A. Sedimentary soil-mixed range influences (new).

1. To determine the influence of grazing and the effectiveness of control measures on run-off and erosion, by means of comparable, complex watershed studies, duplicate run-off areas, and permanent plots.

2. To determine the effectiveness of present plant cover for regulating run-off and erosion under controlled conditions of slope, soil and different intensities of artificial rainfall, by means of portable apparatus.

3. To determine water losses through plant growth by means of lysimeter and lysiphytometer studies.